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CENTRAL FLOW CONTROL COMPUTER PROGRAM SPECIFICATIONS: VOLUME I INTRODUCTION TO SPECIFICATION SERIES, SYSTEM OVERVIEW

Central Flow Control Design Team
Federal Aviation Administration

September 1976
Final Report

Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Systems Research & Development Service
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16. Abstract

This report contains an introduction to the specifications for the Central Flow Control Computer Program, and presents an overview of the automated system on which the program functions. This report provides a description of the system application, the data processing configuration, program interfaces, system operations, software capabilities, and the remainder of the specification series.

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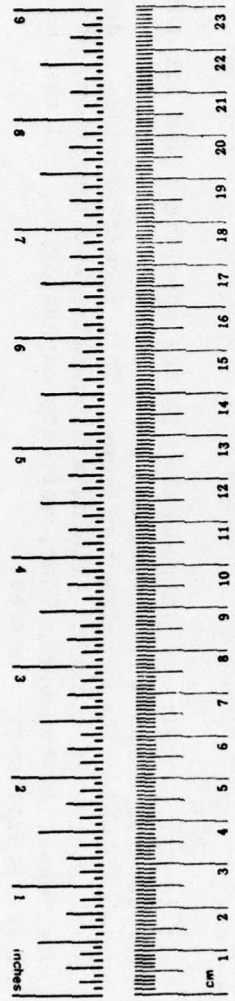
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

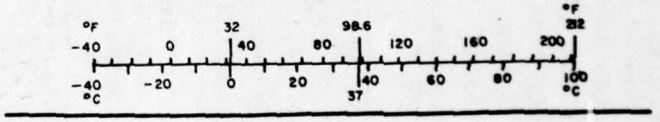
Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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ACKNOWLEDGEMENT

This specification series was prepared by the members whose names are listed above. In performing this work these members were supported by their respective organizations. Inclusion in the above list, however, does not necessarily imply that either the individual or his organization endorses the report.

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AAF - Airway Facilities Service, Federal Aviation Administration
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TABLE OF CONTENTS

1. INTRODUCTION

1.1 Background

The Air Traffic Control System Command Center (ATCSCC) was established in 1970 to oversee the flow of aircraft among Air Route Traffic Control Centers. The ATCSCC's primary objective is the balancing of national air traffic flow to minimize delays without exceeding controller capacity or jeopardizing safety.

The ATCSCC consists of the following functional elements:

- Central Flow Control Function (CFCF)
- Airport Reservation Function (ARF)
- Central Altitude Reservation Function (CARF)
- Contingency Command Post (CCP)

At the present time, the functions of ARF, CARF, and CCP are performed manually.

The Central Flow Control Function (CFCF) has had automation support for some time.* Most recently, in January 1972, an improved version of the automation program named the "Airport Information Retrieval System (AIRS)" was placed in operation by the Transportation Systems Center using a commercial time-sharing computing system. It is designed to operate on a commercial time-share system to provide terminal arrival delay predictions, flow rates for Quota Flow Procedures, and Fuel Advisory Departure (FAD) procedure support. The primary data source for the system is the Official Airline Guide (OAG) published by the R. H. Donnelley Corporation. AIRS uses a Digital Equipment Corporation's (DEC) System 10, time-sharing computer with associated communications interfaces and input/output devices at the ATCSCC.

This specification series will define a substantial improvement to the automation support of the CFCF at the ATCSCC. This will

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* Engineering and Development Program Plan, ATC System Command Center Automation, FAA-ED-11-1A, (to be issued).

be accomplished by providing the ATCSCC with a dedicated International Business Machine's (IBM) 9020A computer system located at the Jacksonville ARTCC. This computer will be provided with a digital data interface with each of the 20 ARTCCs in order to obtain real time inputs that supplement the OAG data base.

1.2 Scope

This document contains the System Overview for the automation of the CFCF. Chapter 2 describes the elements of the Central Flow Control System. Chapter 3 briefly discusses the Central Flow Control Operational Requirements. Chapter 4 contains a brief CFC software architectural overview.

Appendix A contains the list of applicable specifications which comprise the Computer Program Specifications for software Package 1 of the CFCF.

2. THE CENTRAL FLOW CONTROL SYSTEM

2.1 General Description

Normal management of the CFCF is performed at the ATCSCC. The ATCSCC is located in the Federal Office Building 10A at Washington, D.C. The computer for the CFCF is an IBM 9020A, which for convenience of physical housing, is located at the Jacksonville (JAX) ARTCC, Hilliard, Florida. Limited back-up management of the CFCF will be provided at the (JAX) CFC computer to permit a measure of redundancy in the event of failures in the communication or ATCSCC equipments.

A direct digital interface between the input/output devices at the ATCSCC and the (JAX) CFC computer will provide for the rapid exchange of CFC message queries and responses. Digital data channels between the CFC computer and the NAS En Route computing network will also be established.

The basic CFCF reference data is obtained from the Official Airline Guide (OAG) which is released bi-weekly by the R. H. Donnelly Corporation. The CFC computer will be used to prepare the needed data base using its off-line support system. The NAS En Route computing network via the before-mentioned digital data interface will augment the CFC data base in real-time with selected messages.

Thus, flow control personnel at the ATCSCC will have available automation support that will provide a limited capability for predicting flow control problems. Future development efforts are envisioned to enhance the timeliness and extent of the available prediction capability.

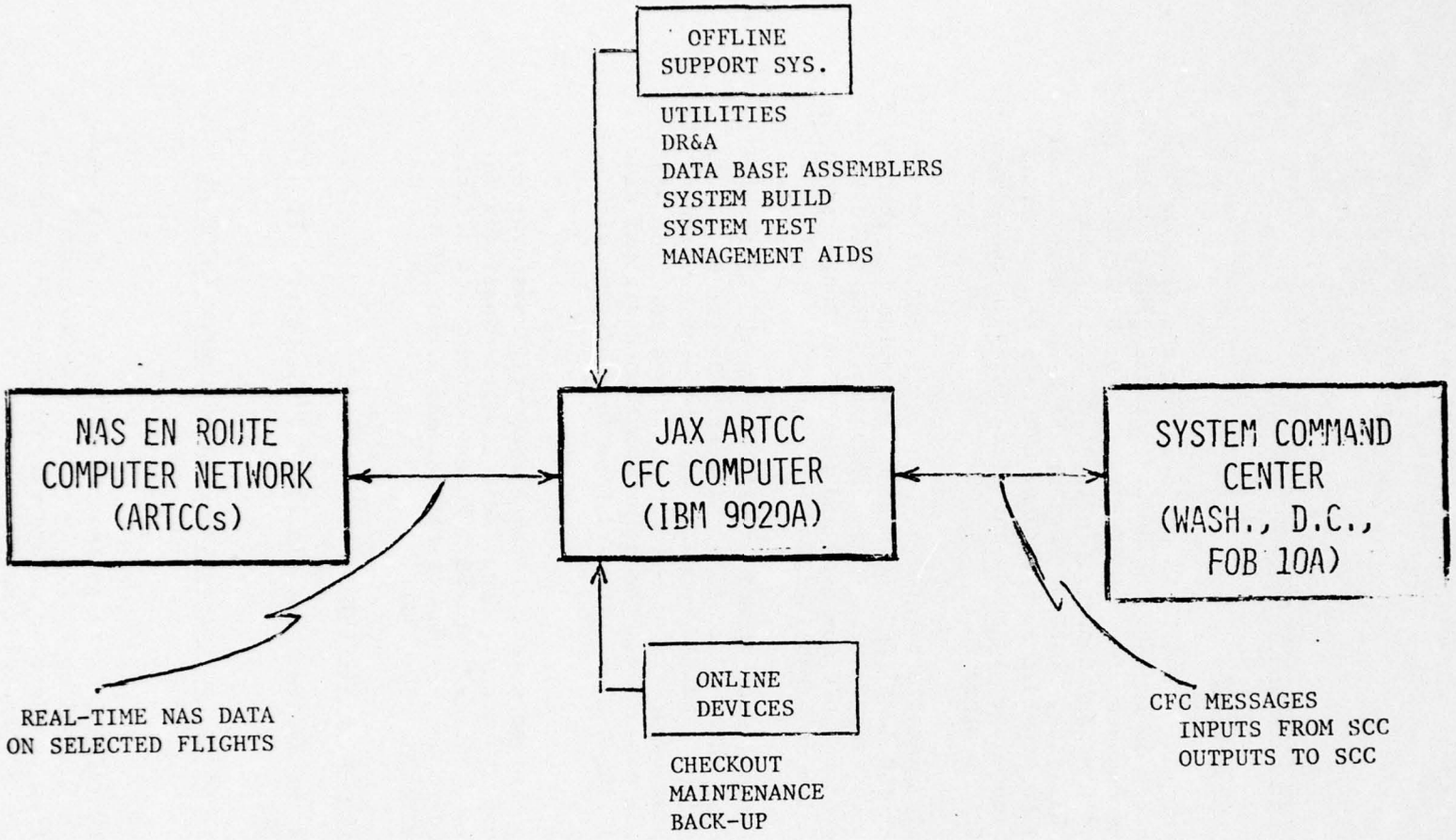
2.2 The System Block Diagram

Figure 2-1 is the system block diagram for the Central Flow Control system.

2.3 The Air Traffic Control System Command Center (ATCSCC)

2.3.1 Role

The role of the ATCSCC is to oversee the flow of aircraft among ARTCCs. The principal objective is to balance nationwide the air traffic flow to minimize delays without exceeding controller capacity or jeopardizing safety.



CFC
SYSTEM BLOCK DIAGRAM

FIGURE 2-1

The ATCSCC consists of the following functional elements:

- Central Flow Control Function (CFCF)
- Airport Reservation Function (ARF)
- Central Altitude Reservation Function (CARF)
- Contingency Command Post (CCP)

This document concerns itself only with the CFCF. Within the constraints that are dictated by the limitations of the informational data base that the CFCF uses, the CFCF attempts to predict potential flow problems. Emphasis is placed on conserving fuel by advising flights that are likely to encounter lengthy airborne delays that such delays should be taken on the ground by delaying their departure.

The ATCSCC presently operates a system called AIRS, the Airport Information Retrieval System*. The primary data source for this system is the information contained in the Official Airline Guide (OAG) plus limited manual data entry by ATCSCC personnel. A major distinction between AIRS and the automation effort to be undertaken is the interface between the CFC computer and the NAS En Route ATC system. This interface will permit that selected messages generated by the NAS En Route ATC system can supplement and/or update the CFCF data base and thereby improve both the timeliness and accuracy of the CFCF problem predictions. Future CFCF automation efforts can be expected to rely on even more extensive data exchange.

2.3.2 ATCSCC Operating Positions

The ATCSCC will have five operating positions that interface with the CFC computer. Each of the five positions will be equipped with identical computer entry/output devices. These are:

- Computer Entry Device
- Computer Readout Device
- Low Speed Printer

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* Airport Information Retrieval System (AIRS) System Design, FAA-RD-73-77, July 1973, DOT, FAA.

In addition, there will be one medium speed printer and two five-hole paper tape reperforators at the ATCSCC.

2.4 The Data Processing Configuration

2.4.1 The CFC Computer

The CFC computer is an IBM 9020A. The initial CFC system will operate with the following basic configuration of hardware:

- Two 9020A computer elements
- Two 9020A input/output control elements
- Five 9020A model 08 storage elements (65K words)
- One peripheral adapter module
- One tape control unit with 3 drives
- One disk control unit with 2 drives
- One System Console
- One high-speed printer
- One integrated control unit
- Two printer/keyboards
- One card reader/punch

2.4.2 Input/Output Devices

I/O devices are provided at JAX to:

- support computer program development, maintenance and checkout,
- provide a redundant output capability in case of communication interface failure with the ATCSCC or failure(s) of the output equipment at the ATCSCC,
- provide output capability for Data Reduction and Analysis reports.

The I/O devices at Jacksonville include:

- High-speed printer
- Printer keyboard (IOT)
- Card reader/punch
- Central Flow Controller's console including a computer readout device, computer entry device and a printer
- Five-hole paper tape reperforator

ATCSCC

The I/O devices at the ATCSCC are:

- Five Central Flow Controller's consoles, each including a computer readout device, computer entry device and a console printer
- Medium-speed printer
- Five-hole paper tape reperforator

2.4.3 Data Processing Configuration Diagram

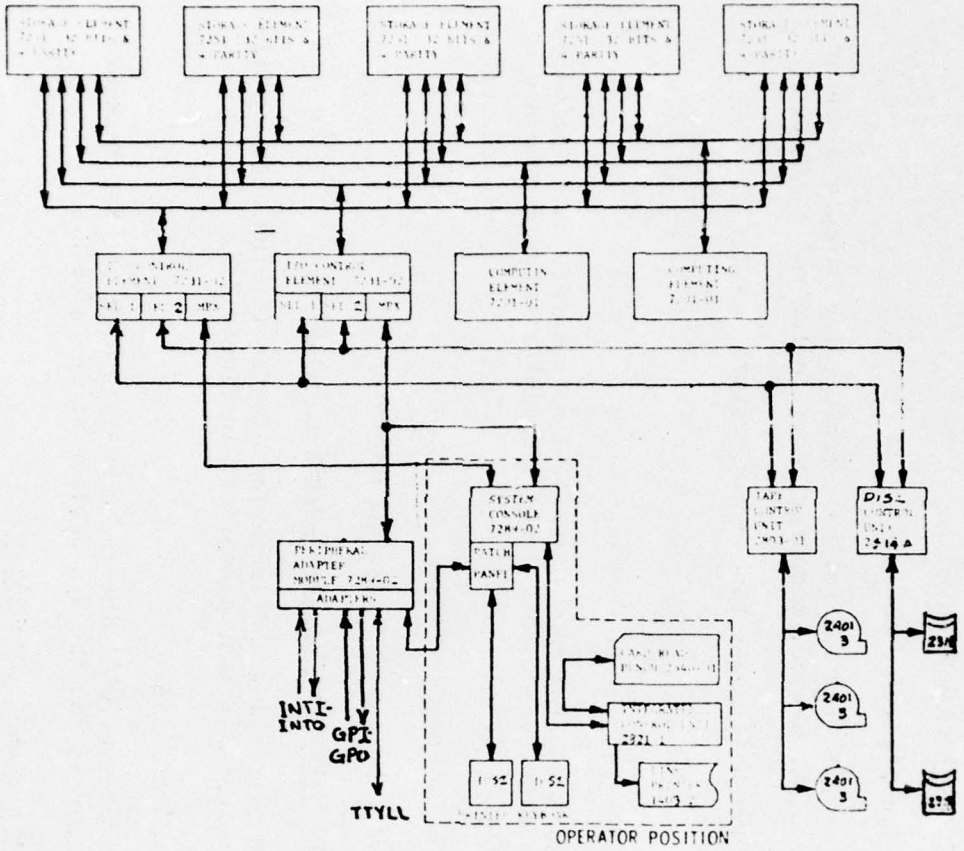
The data processing configuration diagram for the Jacksonville computer installation is depicted in Figure 2-2.

2.5 CFC Interfaces

The CFC computer will interface on-line with the NAS En Route Stage A system and the I/O devices at the ATCSCC.

2.5.1 Functional Capability

In order to augment the static OAG-derived data base within the CFC computer and to enhance the timeliness and accuracy of that data base, an interface with the 20 ARTCC computers will be provided. This interface is intended to have minimal impact on the existing NAS En Route resources. An interface configuration which uses a limited number of ARTCC computers as focal points to gather information from the other ARTCCs and forward the data to the CFC computer at JAX is proposed. This configuration represents a "Store-and-Forward" configuration.



DATA PROCESSING CONFIGURATION DIAGRAM
(JACKSONVILLE CFC INSTALLATION)

FIGURE 2-2

Real-time inputs will be received from the NAS En Route Stage A system for flights that are proceeding to a limited set of specially identified airports, called pacing airports*. The real-time input messages are:

- flight plans for non-air-carrier flights proceeding to pacing airports.
- departure messages for all flights proceeding to a pacing airport.
- remove strip messages for all cancelled flights that had planned to land at a pacing airport.

2.5.2 Interface Description

NAS-CFC

The twenty ARTCCs serving the 48 contiguous United States will generate messages for selected flight plans for forwarding to the CFC computer. Five of the twenty NAS computers have been designated as store-and-forward focal points to concentrate data from several centers before transmission to the CFC computer. Two NAS computers have been designated as relays to pass data on to the nearest store-and-forward focal point. Thus, CFC messages between NAS facilities will utilize existing computer-to-computer communication links. The five store-and-forward computers are:

Los Angeles (ZCL)
Kansas City (ZCK)
Indianapolis (ZCI)
Jacksonville (ZCJ)
Washington (ZCW)

The two relay computers are:

Salt Lake City (ZCU)
New York (ZCN)

---

* Pacing airports are selected on the basis of generating the preponderance of air traffic delays within the ATC system.

New computer to computer communication links are expected to be established between the NAS computers at the five store-and-forward ARTCCs and the CFC computer housed at the Jacksonville ARTCC. The CFC Interface Diagram, Figure 2-3, shows how a message is forwarded from any ARTCC to the CFC computer.

CFC-SCC

New, point-to-point, communication link(s) are expected to be established between the SCC devices at FOB 10A in Washington, D.C., and the CFC computer at the Jacksonville ARTCC.

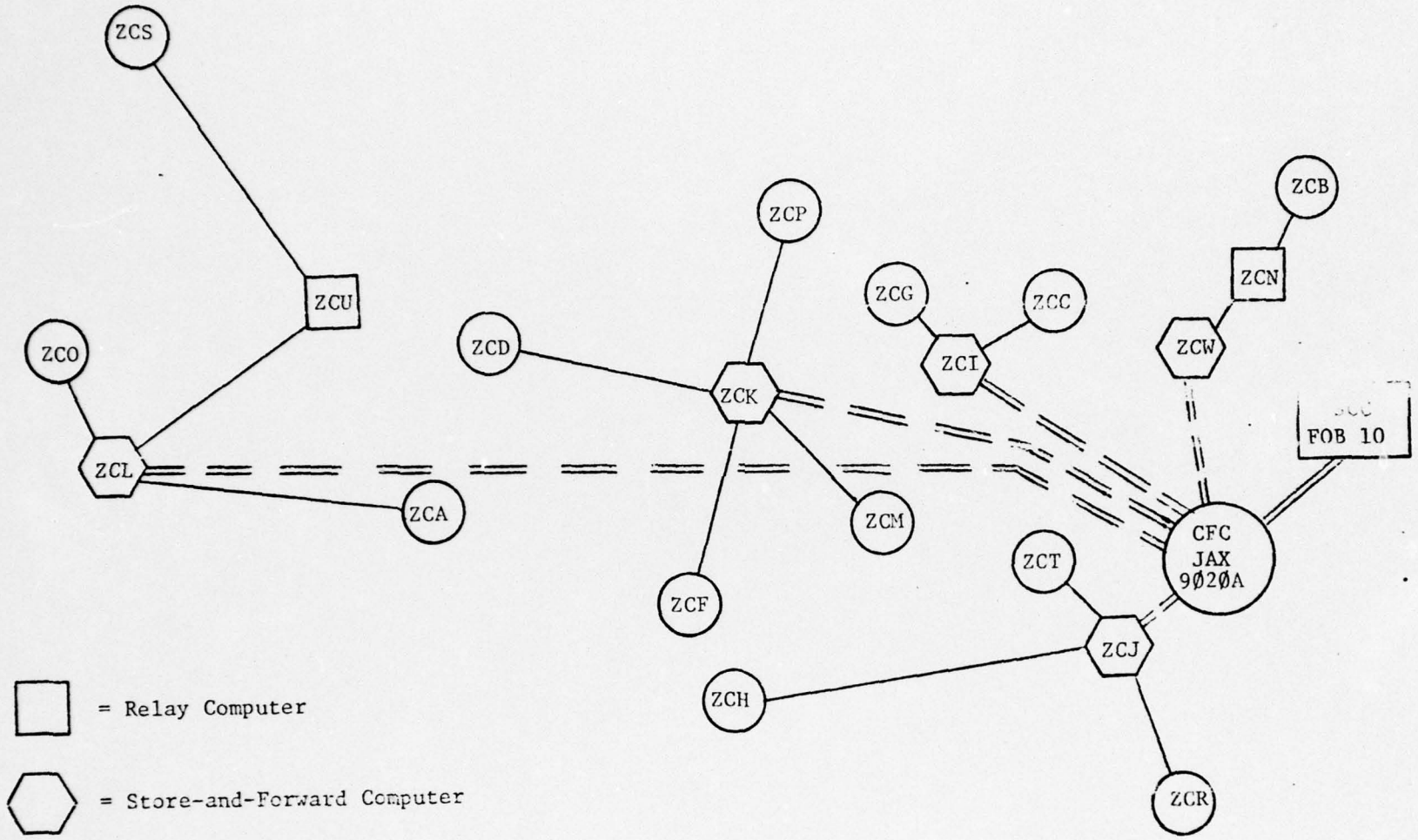


FIGURE 2-3

CFC INTERFACE DIAGRAM

3. CENTRAL FLOW CONTROL OPERATIONAL DESCRIPTION

3.1 Development Packages

The input/output messages described in Section 3.3 are the operational messages that will be implemented in the initial CFC package. Detailed operational message requirements for the initial CFC package are contained in "The Central Flow Control System Requirements" document. The initial package will operate within the computing complex configuration defined in Section 2.4.1. Future CFC packages are expected to require some computing hardware augmentation. Potential considerations for future development packages are mentioned.

3.2 System Response

The CFC is not a strict real-time control function. Hence, lenient startup/startover and message response requirements are envisioned. Automatic restart provisions need not necessarily include automatic configuration of the computing complex in case of computer failure*; however, time response for startover is not considered critical.

The data base for CFC will normally be regenerated (off-line) whenever the OAG changes.

3.3 Input-Output Messages

3.3.1 Central Flow Control Message Summary

A number of input and output messages have been defined for the initial central flow control package to aid the central flow controller(s) in the execution of his duties. All messages belong to one of four major message categories. These categories are:

Messages that:

- count data (Data Count)

- list data (Data List)

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* Communications provisions in case of CFC computer failure need further consideration.

- predict events (Simulation)

- update the data base (Data Base Update)

Data Base Update can occur via messages normally entered by flow controllers at the ATCSCC or via messages received from the NAS En Route Stage A system.

A summary of all presently defined messages is shown in Table 3-1. Abbreviated descriptions for each message follow.

3.3.2 Data Count Messages

The Data Count Message category consists of a number of messages which cause the data base to be searched and specific counts of data to be tabulated. The messages are:

DEMD - Departure Demand

The Departure Demand message tabulates hourly counts of aircraft departing a designated airport(s) on the current day.

DEMA - Arrival Demand

The Arrival Demand message tabulates hourly counts of aircraft that are scheduled to arrive at a designated airport(s) on the current day. Subtotals for currently airborne aircraft are included.

DESD - Future Departure Demand

The Future Departure Demand message tabulates hourly counts of aircraft departing a designated airport(s) on a future day(s).

DESA - Future Arrival Demand

The Future Arrival Demand message tabulates hourly counts of aircraft that are scheduled to arrive at a designated airport(s) on a future day(s).

FIXL - Fix Loading

The Fix Loading message tabulates hourly counts of aircraft scheduled to cross a designated (adapted) fix(es). Subtotals for currently airborne aircraft are included.

TABLE 3-1

CFC MESSAGE SUMMARY

DATA COUNT	DATA LIST	SIMULATION	DATA BASE UPDATE
DEMD Departure Demand	LISD List Departures	ARRD Arrival Delay Prediction	ACTV Activate Flight Plan
DEMA Arrival Demand	LISA List Arrivals	FADP Fuel Advisory Departure Block Times	INHB Inhibit Flight Plan
DESD Future Departure Demand	LIFP List Flight Plan	FADF Fuel Advisory Departure Estimated Departure Clearance Times	FPSD Add Flight Plan CXSD Delete Flight Plan
DESA Future Arrival Demand	CAPL List Landing Capacities	FADT Fuel Advisory Departure Test	CAPS Set Landing Capacities
FIXL Fix Loading	GAEL List General Aviation Estimates	QFLW Quota Flow First Tier	GAES Set General Aviation Estimates
DLDY Departure Delay Test		QFLZ Quota Flow by Zone	NAS Messages FP Flight Plan DM Departure RS Remove Strip

DLDY - Departure Delay Test

The Departure Delay Test message applies an entered delay factor to aircraft departing a designated pacing airport and tabulated hourly counts of the resulting predicted arrival demand at another designated pacing airport.

3.3.3 Data List Messages

The Data List Message category consists of a number of messages which cause the data base to be searched and specifically requested data to be listed. The messages are:

LISD - List Departures

The List Departures message tabulates information on departing aircraft from one or all designated pacing airports within an ARTCC.

LISA - List Arrivals

The List Arrivals message tabulates information on planned arriving aircraft at one or all designated pacing airports within an ARTCC. Output data are sorted by planned arrival time.

LIFP - List Flight Plan

The List Flight Plan message tabulates all active data for a designated flight that involves a designated or all pacing airports.

CAPL - List Landing Capacities

The List Landing Capacities message tabulates the stored values of hourly landing capacities for a designated or all pacing airports. Landing capacities currently in use are separately tabulated from the normally adapted values.

GAEL - List General Aviation Estimates

The List General Aviation Estimates message tabulates the stored values of hourly landing capacities for a designated pacing airport or a center. GA estimates currently in use are separately tabulated from the normally adapted values.

3.3.4 Simulation Messages

The Simulation Message category consists of a number of messages that cause delay and/or capacity predictions to be computed and tabulated. The messages are:

ARRD - Arrival Delay Prediction

The Arrival Delay Prediction message computes anticipated arrival delays for flights arriving at a specified airport. Output data are ordered by hourly prediction, identifies currently airborne flights and includes average as well as anticipated peak delay data.

FADP - Fuel Advisory Departure (FAD) Block Times

The FADP Block Times message is used in conjunction with FAD procedures. Output data includes the landing capacities used in the computations, "Quota" reports based on stipulated holding stack sizes and ECDT block time assignments.

FADF - Fuel Advisory Departure (FAD) Estimated Departure Clearance Times (ECDT)

The FAD ECDT message generates the information obtained via the FADP message but in addition generates output data by flight to be used for "energy conservation" flow control.

FADT - Fuel Advisory Departure (FAD) Test

The FAD Test message generates a one-time output, typically used to test and evaluate the need for implementing FAD procedures.

QFLW - Quota Flow First Tier

The Quota Flow First Tier message assigns first tier quotas with respect to an identified pacing airport based on known traffic demand and landing capacity.

QFLZ - Quota Flow by Zone

The Quota Flow by Zone message assigns quotas with respect to an identified pacing airport based on the requested zone and known traffic demand and landing capacity.

3.3.5 Data Base Update Messages

The Data Base Update Message category consists of messages which change or augment the stored data base. One group of these messages normally are entered by flow control personnel; the second group of these messages are automatically generated by the NAS En Route Stage A system. The first group of messages are:

ACTV - Activate Flight Plan

The Activate Flight Plan message cancels the inhibition of data retrieval on specified airline or individual flight effective the current or a specified data.

INHB - Inhibit Flight Plan

The Inhibit Flight Plan message inhibits the retrieval of data for specified airline or individual flight effective the current or a specified date.

FPSD - Add Flight Plan

The Add Flight Plan message permits ATCSCC personnel to add air carrier flight plan(s) to the data base.

CXSD - Delete Flight Plan

The Delete Flight Plan message cancels identified flight data from the data base.

CAPS - Set Landing Capacities

The Set Landing Capacities message replaces the "current" values of landing capacities for the identified pacing airport for the stipulated time interval.

GAES - Set General Aviation Estimates

The Set General Aviation Estimates replaces the "current" values of landing capacities for the identified pacing airport or center for the stipulated time interval.

The Data Base Update message generated by the NAS En Route Stage A system are:

FP - Flight Plan

The Flight Plan message forwards to CFC non-air-carrier flight plan data whenever a flight plan is entered into NAS that plans to land at a pacing airport.

DM - Departure

The Departure message forwards to CFC the actual departure time for any flight that is planning to land at a pacing airport.

RS - Remove Strip

The Remove Strip message notifies CFC whenever a proposed departure flight that had planned to land at a pacing airport is cancelled.

3.4 Future Development Packages

Future software packages of CFC will provide added functional capabilities. Package 2 remains undefined at the time this document is issued. However, functions currently being considered for Package 2 include:

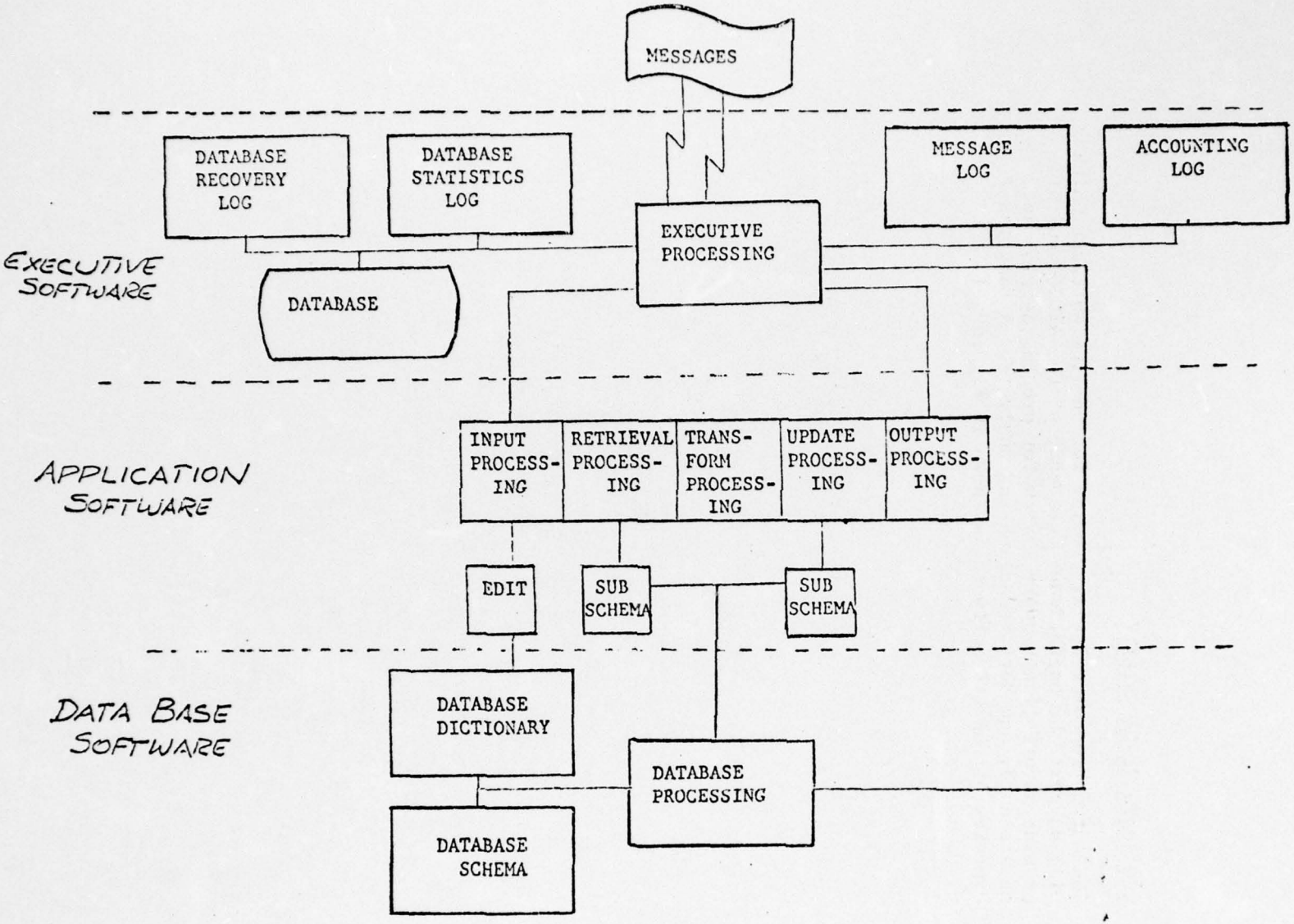
- Automatic Reconfiguration
- Automatic Reconfiguration under program control (additional hardware)
- TTY Network output from either JAX or ATCSCC (operator requested or program control)
- Edit capability (output first to ATCSCC - changes made before output to communications network)
- General Information message input
- Graphic capability
- Additional NAS inputs (e.g., arrival messages, reroutes, etc.)

Functions desired at a future date that are currently being considered to be provided not before Package 3 include:

- Traffic loading analysis using en route fixes
- Airframe to flight identification correlation
- Activation of international flights

4. CFC SOFTWARE CAPABILITY

The automation of CFC will provide for on-line software which will support the operational personnel at the ATCSCC and will provide an off-line support system for program development, maintenance, and data reduction and analysis. A functional overview of the CFC software is shown in Figure 4-1.



CFC FUNCTIONAL OVERVIEW

FIGURE 4-1

APPENDIX A

CFC PACKAGE 1 SPECIFICATION LIST

Volume I: Central Flow Control Computer Program Specifications: Introduction to Specification Series, System Overview

Volume II: Central Flow Control Computer Program Specifications: Application Program Specification

Volume III: Central Flow Control Computer Program Specifications: Off-Line Support Subsystem Specification

Volume IV: Central Flow Control Computer Program Specifications: Data Base Subsystem Specification

Volume V: Central Flow Control Computer Program Specifications: Executive Subsystem Specification